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Hiromatsu

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(54) **CLAMP APPARATUS**

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B25B 5/04 (2006.01)

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(58) **Field of Classification Search** 269/24–27, 269/32, 201, 228, 238
See application file for complete search history.

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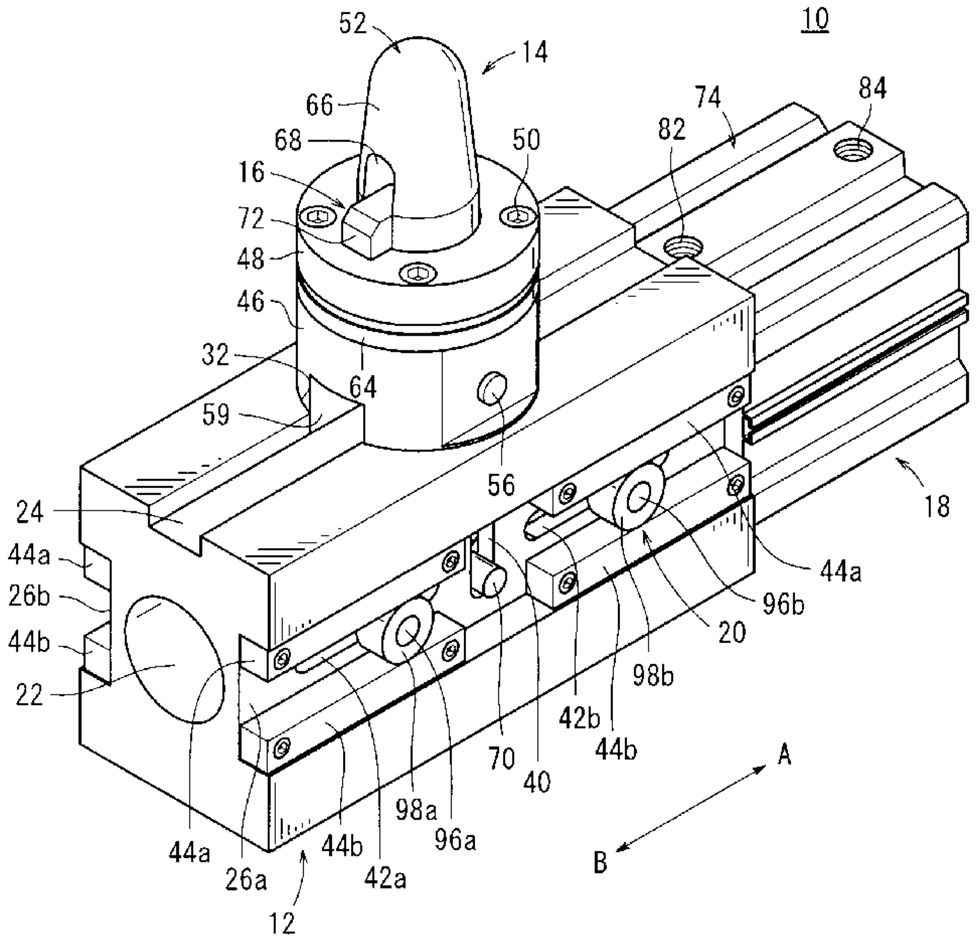
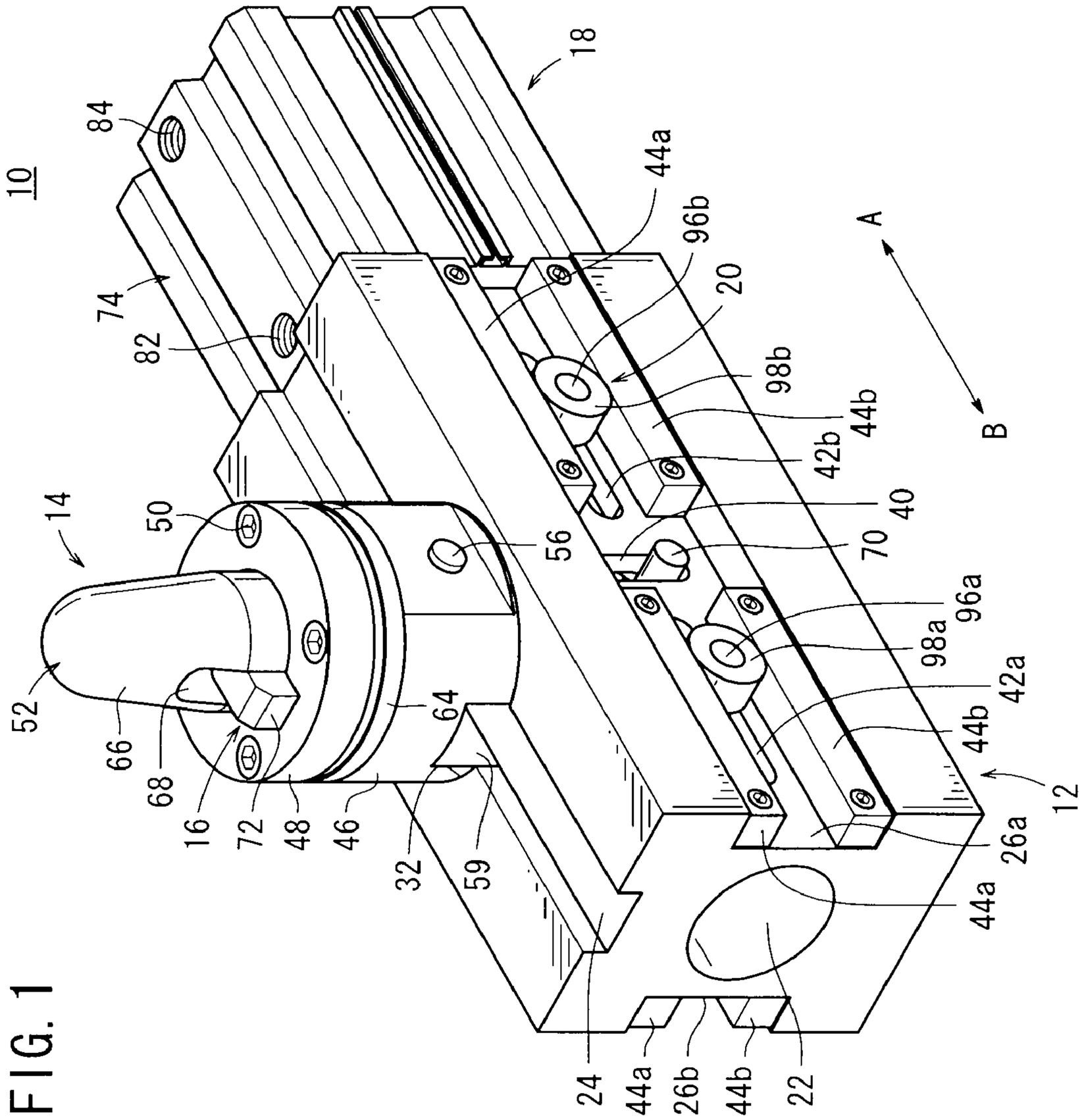
(57) **ABSTRACT**

A clamp apparatus includes a clamp unit capable of retaining a workpiece, a cylinder driven under the supply of a pressure fluid, and a drive force transmission mechanism, which is capable of transmitting a drive force from the cylinder to the clamp unit. The drive force transmission mechanism includes a guide body disposed displaceably inside of a body, two pairs of rollers retained rotatably on both side surfaces of the guide body, and a spindle inserted through a second link groove of the guide body that rotatably supports a clamp arm. The clamp arm is rotatably operated and is capable of clamping the workpiece under a displacement action of the guide body.

9 Claims, 12 Drawing Sheets

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98a
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A
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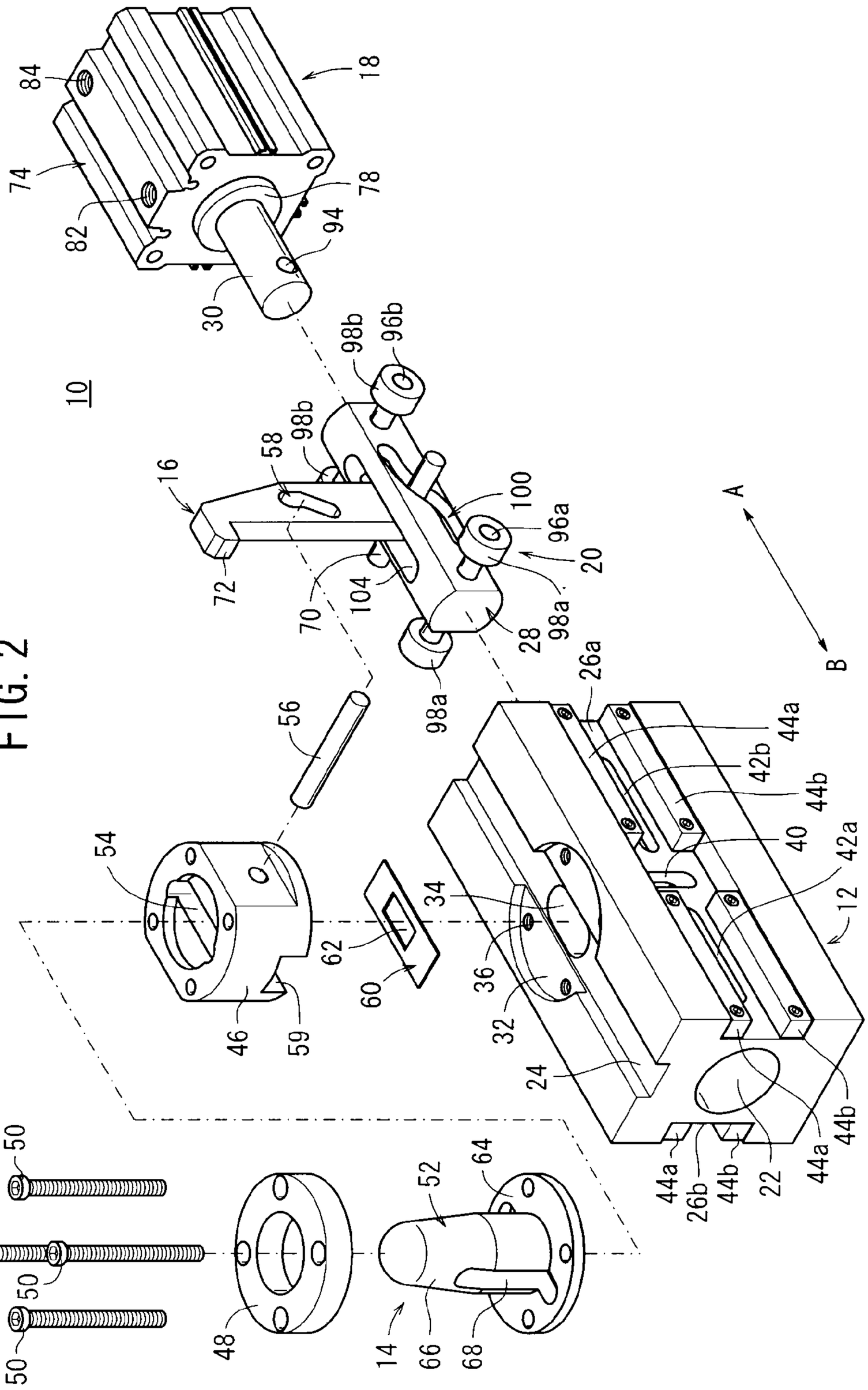
FIG. 1

FIG. 2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98a
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B
56
26a
54
44a
42b
44b
40
42a
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62
60
36
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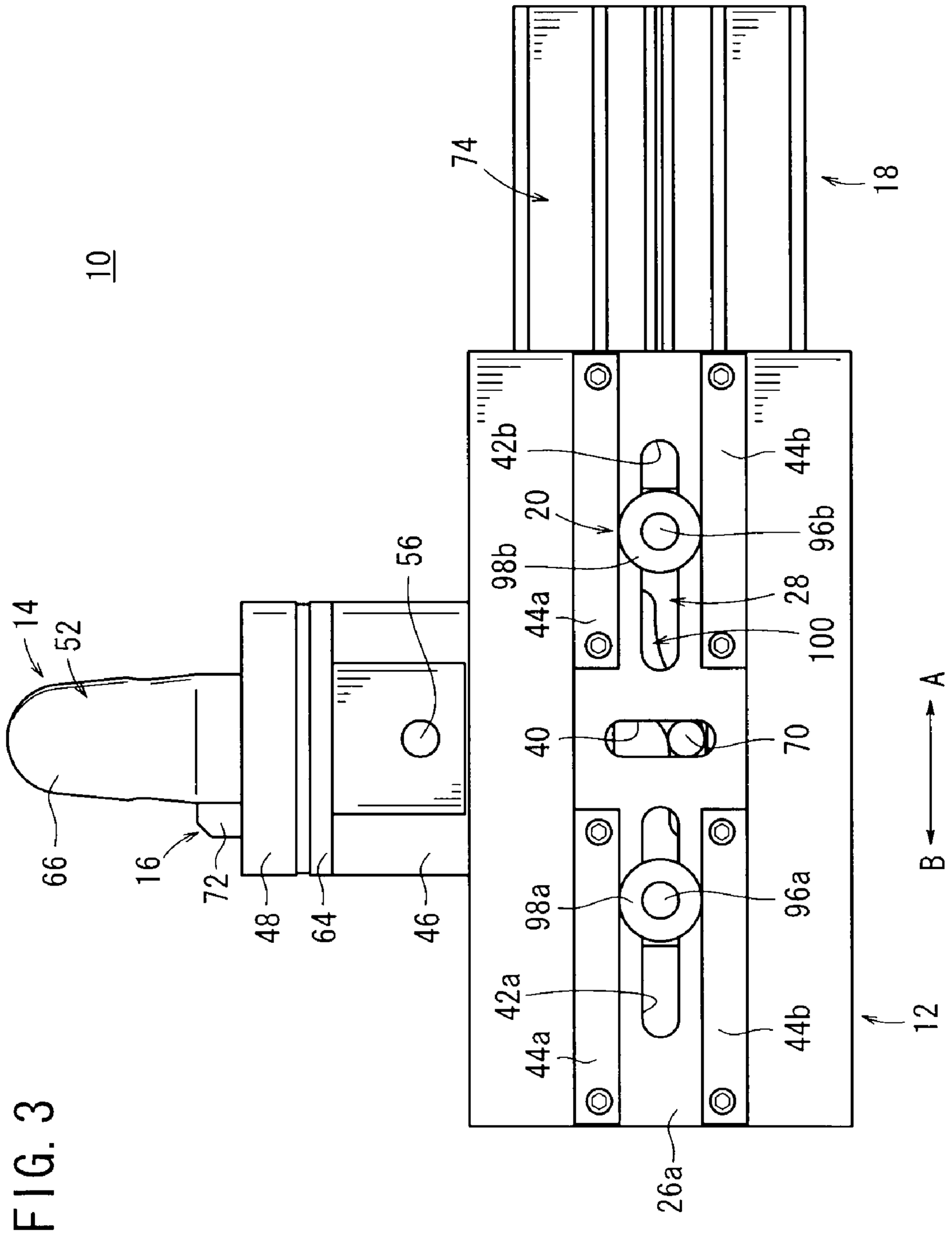
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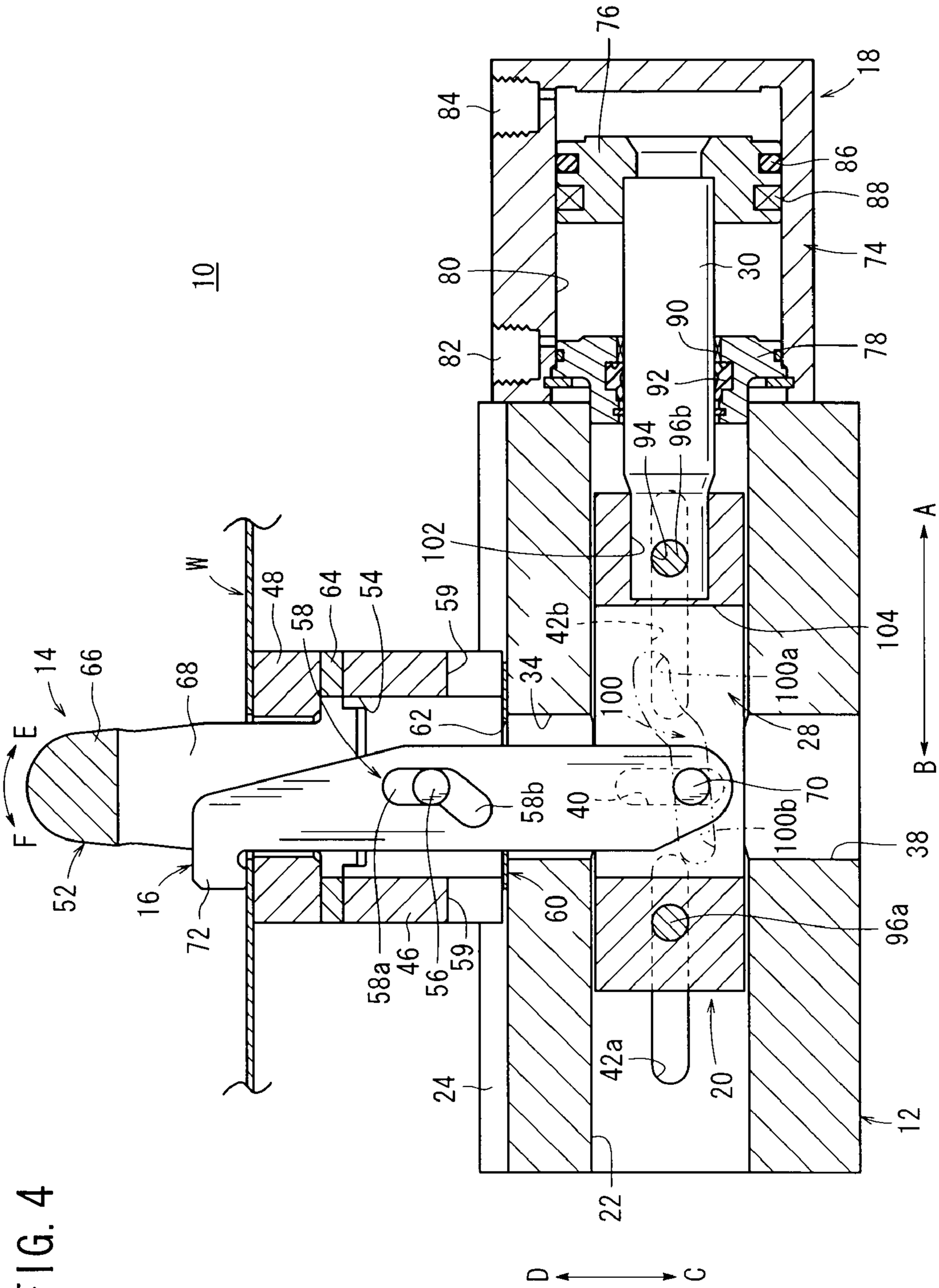
FIG. 3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96a
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100a
100b
102
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W
A
B
C
D
E
F

FIG. 4

FIG. 5

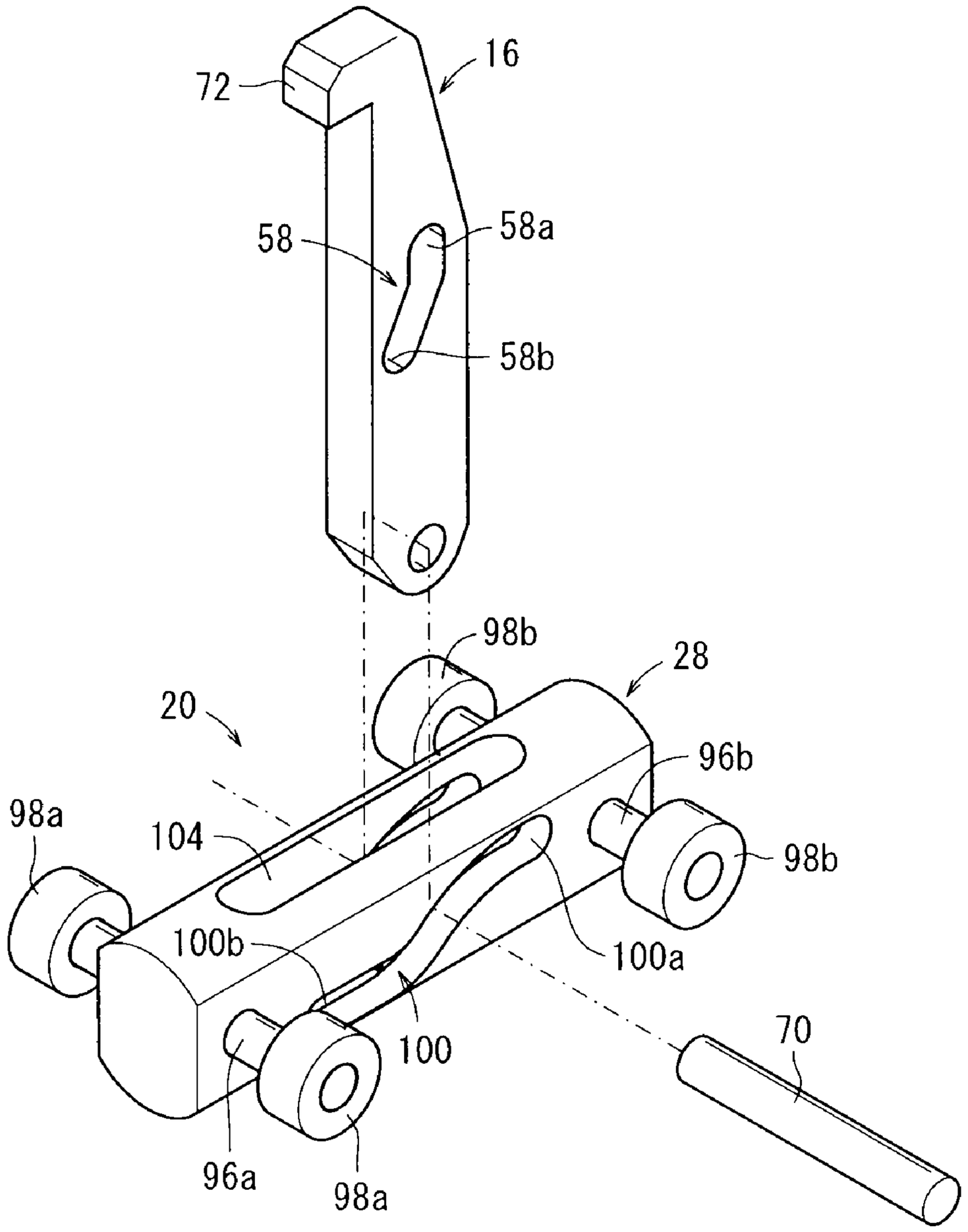
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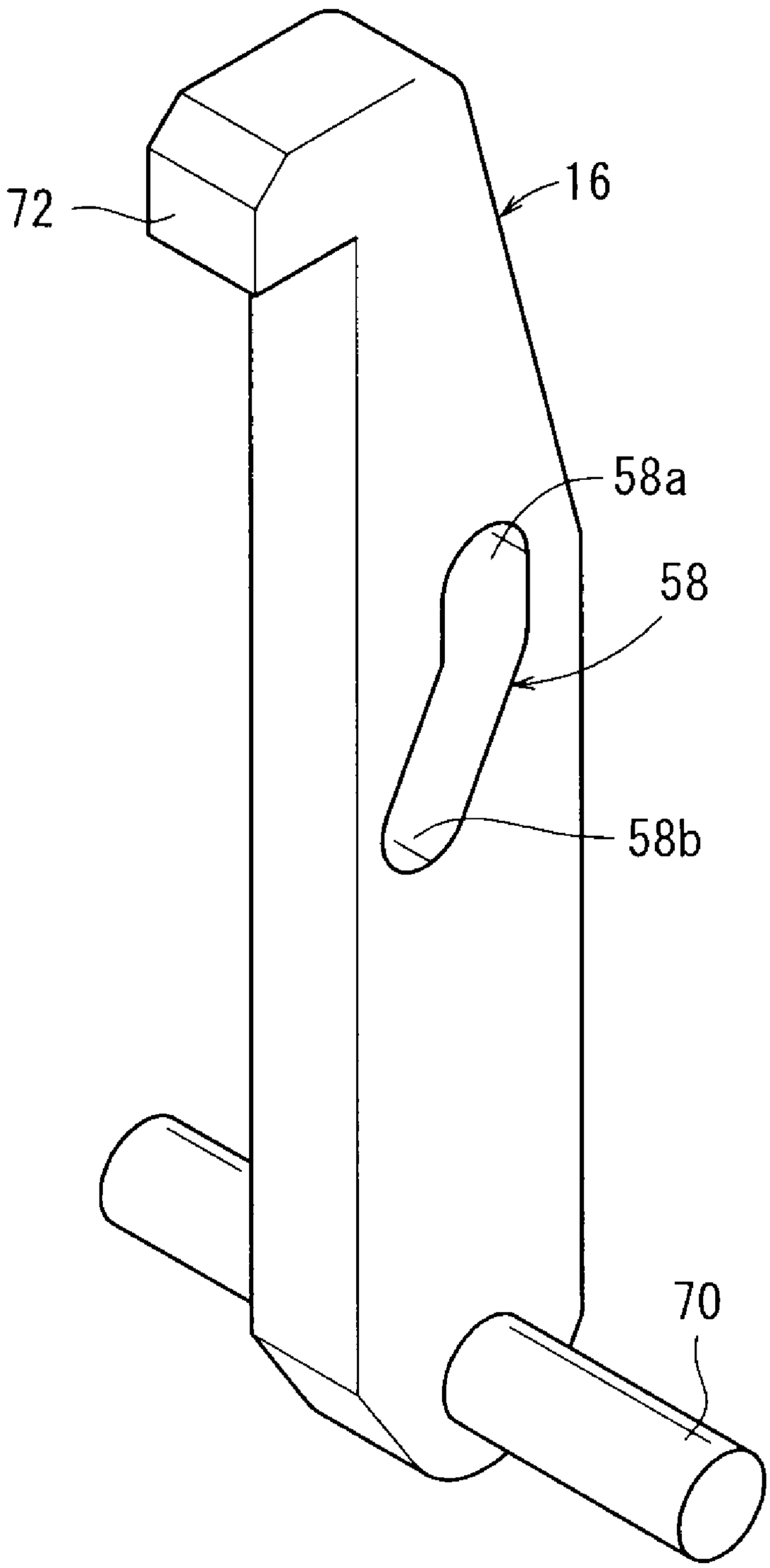
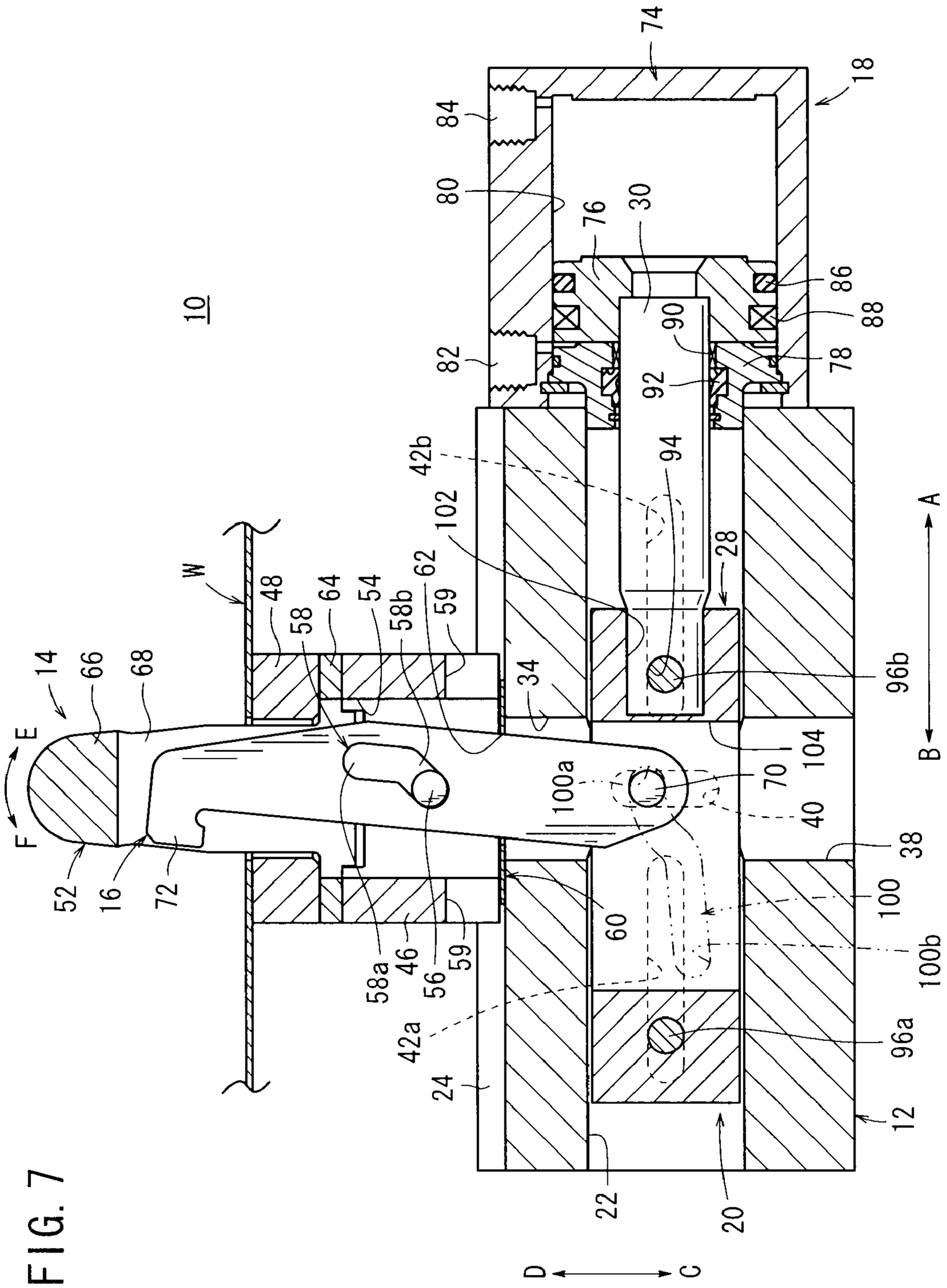
FIG. 6

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28
14
66
68
34
96b
A
B
E
F
52
16
72
100a
70
104
40
38
60
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42a
24
96a
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12
22
20
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C

FIG. 7

FIG. 8

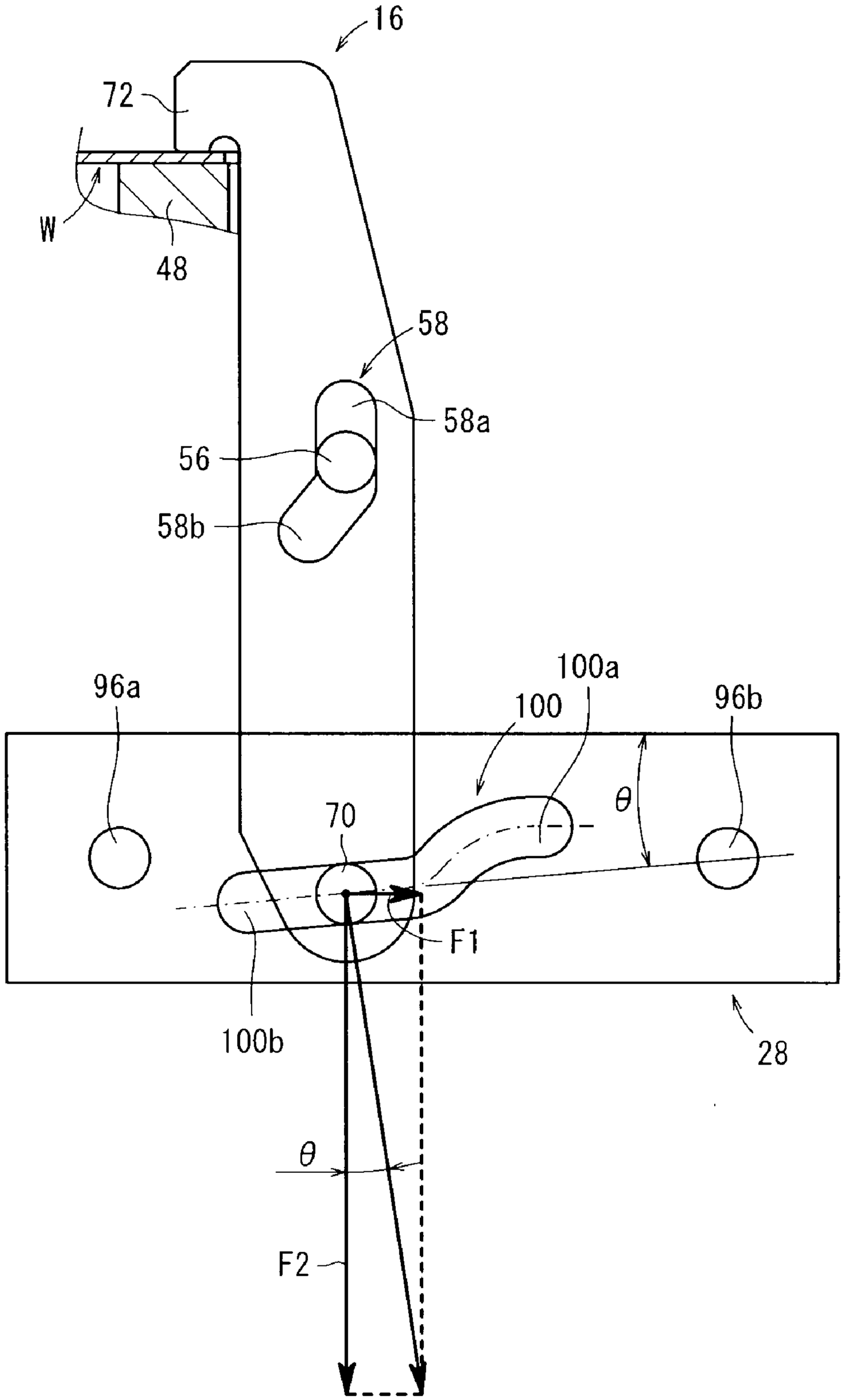
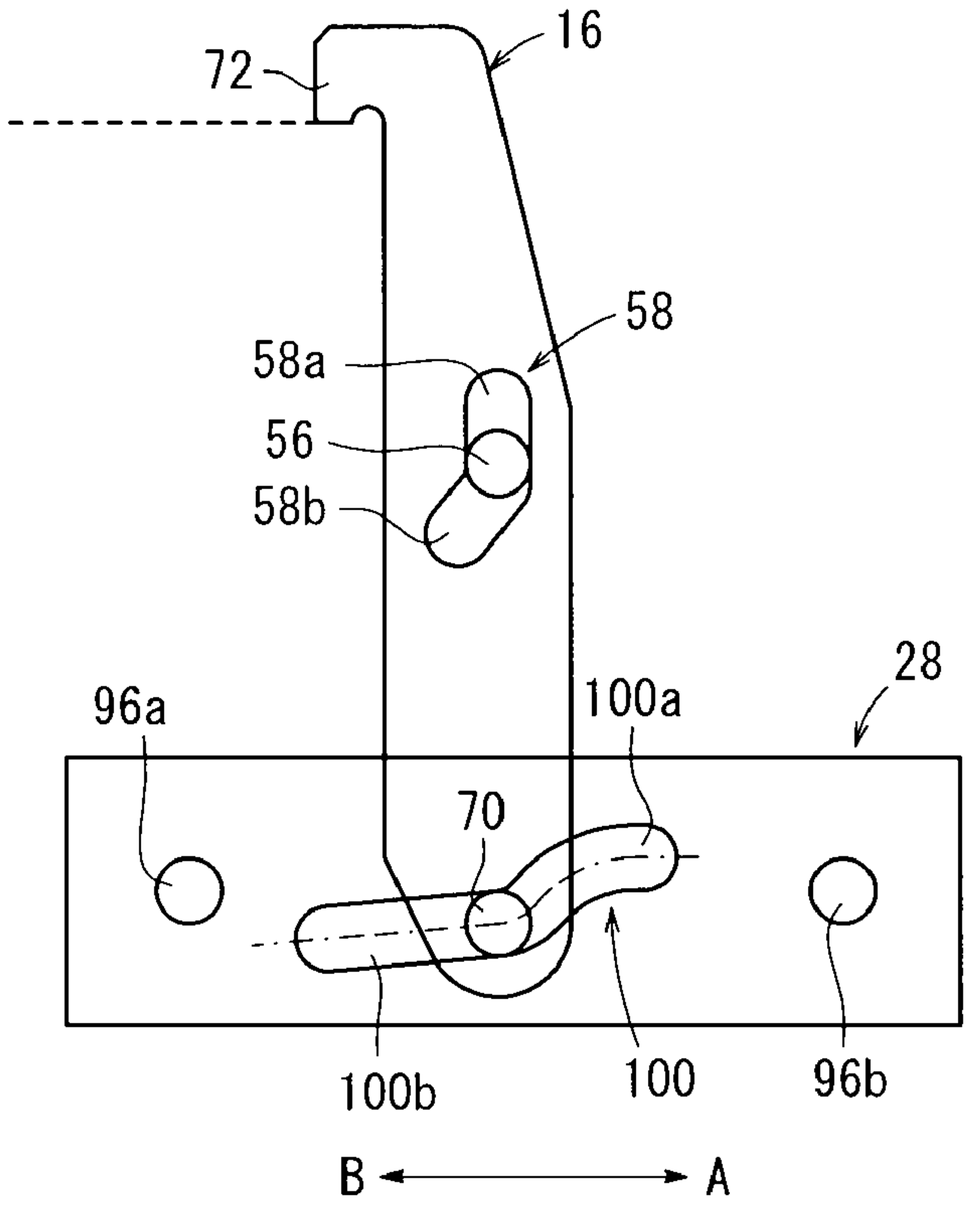


FIG. 9A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58a
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96a
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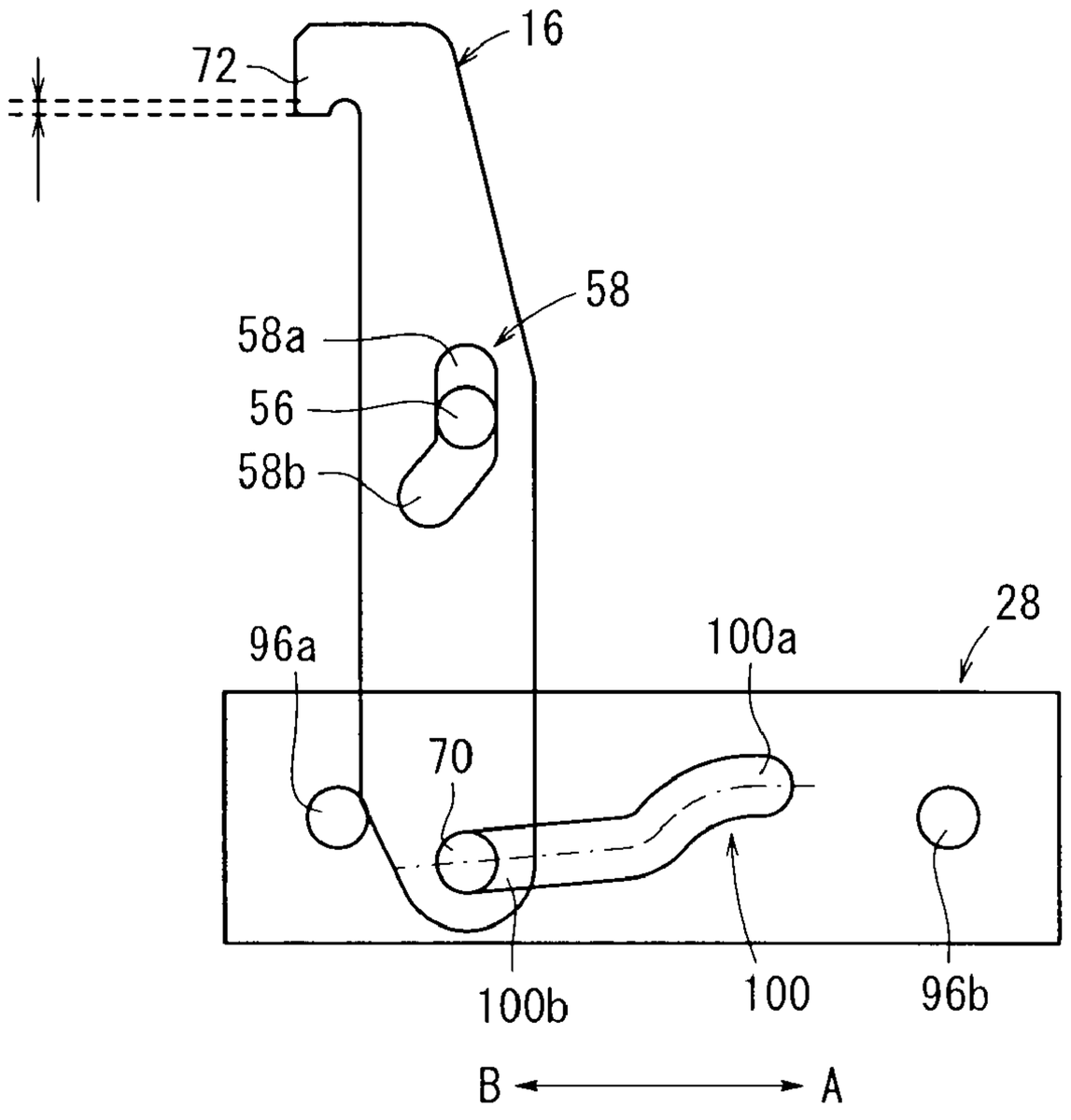
70
100b
100
96b
B
A

FIG. 9B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B
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FIG. 10A

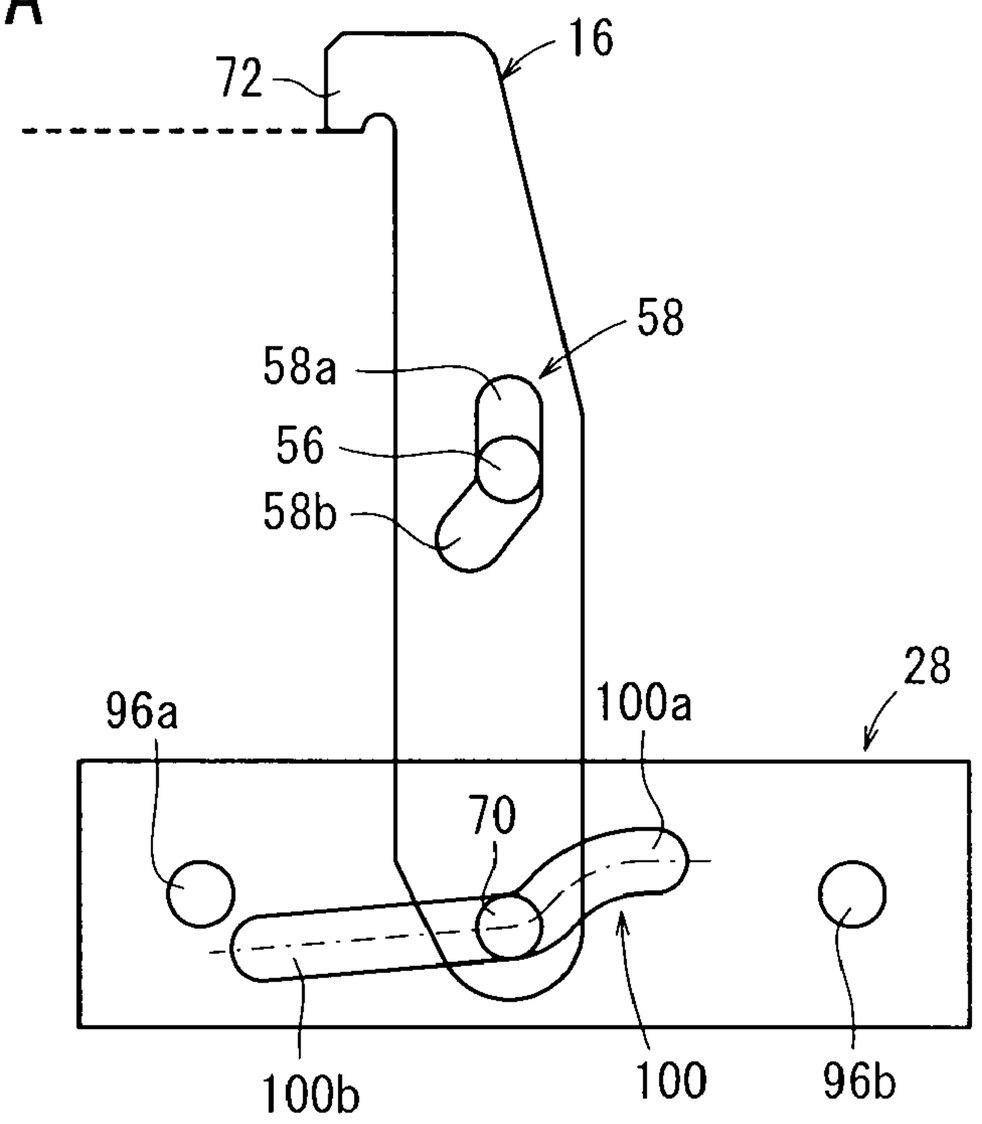
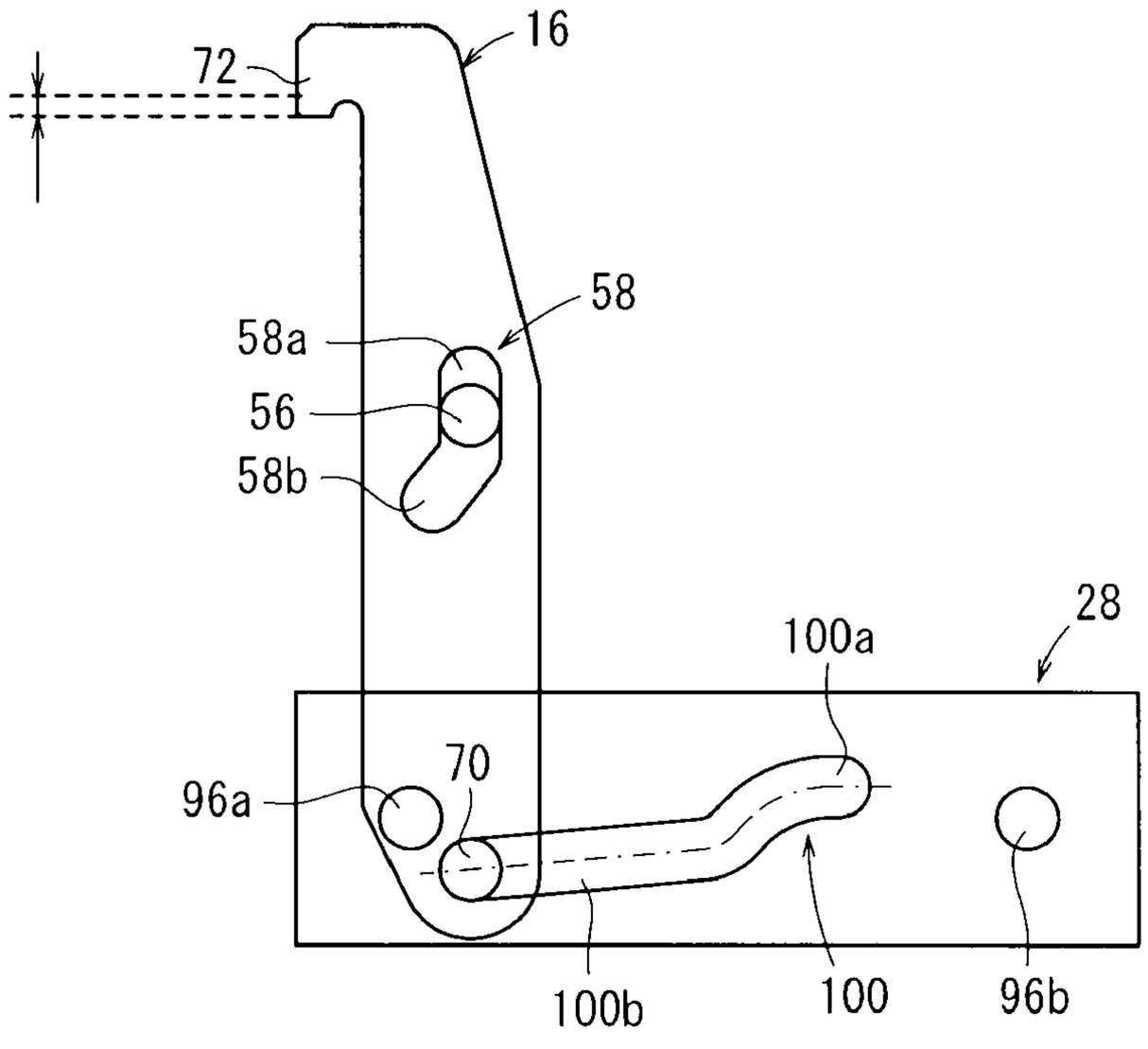
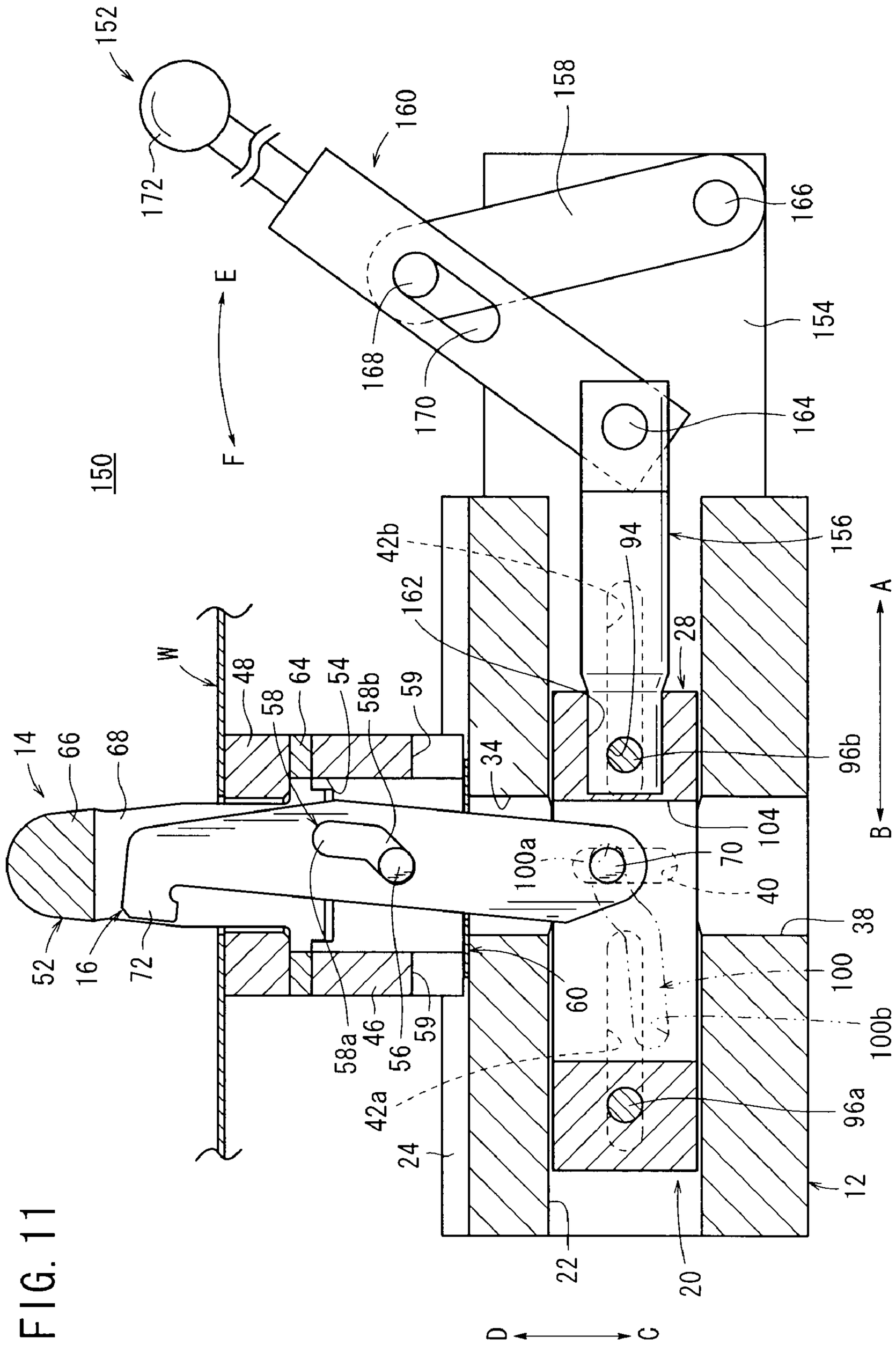


FIG. 10B

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64
54
58b
59
58
14
66
68
34
96b
104
70
100a
40
38
52
16
72
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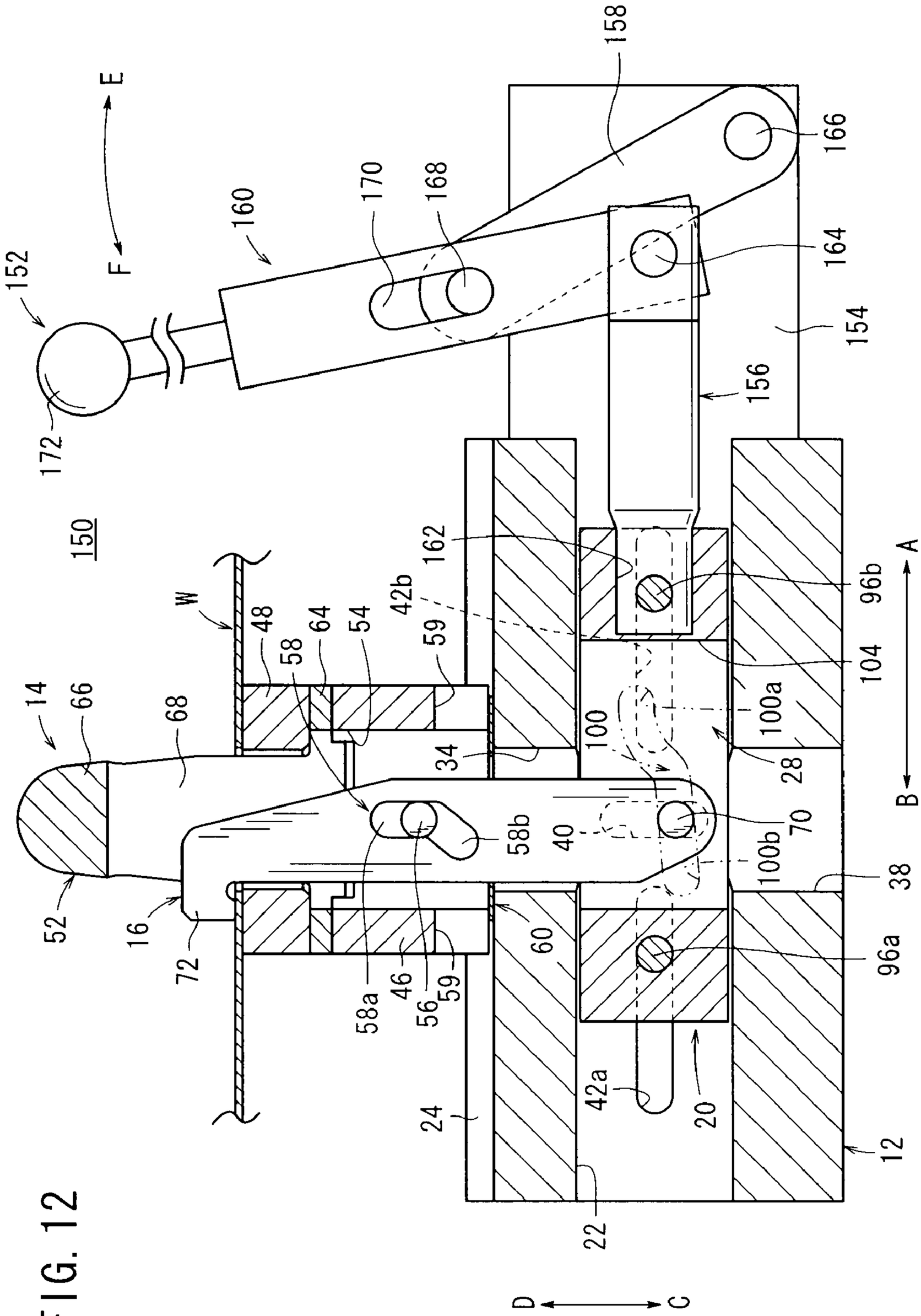
58a
46
56
59
42a
24
100b
96a
12
22
20
D
C

FIG. 11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54
58
14
66
68
100a
100
34
28
58b
40
70
100b
38
52
16
72
60
96a
58a
46
56
59
42a
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24
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FIG. 12

CLAMP APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a clamp apparatus, which is capable of retaining a workpiece by a clamp arm through a drive force of a driving section.

2. Description of the Related Art

Heretofore, for example, when structural components of an automobile or the like are welded, a clamp apparatus is used for clamping the structural components.

In this type of clamp apparatus, for example, a piston is displaced under the supply of air, thereby causing rotary movement of a clamp arm through the piston for clamping the workpiece. However, in a state in which the workpiece is clamped, in the event that the supply of air is halted for some reason, the clamped state of the clamp arm with respect to the workpiece becomes released and the held state of the workpiece cannot be maintained, thus resulting in the workpiece being dropped from the clamp apparatus or the like.

In response to the aforementioned problems, for example, a clamp apparatus is known, which is equipped with a locking mechanism capable of regulating the rotary movement of a clamp arm. As disclosed in Japanese Laid-Open Patent Publication No. 2005-061526, in such a clamp apparatus, a lock rod is connected to a piston that slides in a cylinder body and is displaced integrally with the piston, while in addition, the clamp arm is disposed rotatably through a toggle mechanism on a piston rod connected to the piston, whereby the clamp arm is operated to open and close by displacement of the piston.

Further, a locking cylinder is disposed displaceably in a head cover of the cylinder body, the locking cylinder being disposed perpendicular to the axis of the cylinder body, with a locking piston disposed for displacement in the interior thereof. In addition, the locking piston is urged toward the side of a lock rod by a locking spring, such that by insertion of the locking piston into a recess of the lock rod, displacement of the lock rod is regulated along with regulating the rotary movement of the clamp arm.

However, in the aforementioned conventional technique, the clamp arm is stopped by insertion of the locking piston into the recess of the lock rod, which is urged by means of the locking spring. As a result, the clamping force applied to the workpiece tends to be small. In addition, in the case that a variance occurs in the thickness of the workpiece, the clamped state becomes unstable, and there is a fear that the workpiece may be subjected to shifting and cannot be positioned at a desired position.

Further, because the locking cylinder, including the locking spring and the locking piston, must be assembled in the clamp apparatus, the structure of the clamp apparatus is complicated and made larger in scale.

SUMMARY OF THE INVENTION

A general object of the present invention is to provide a clamp apparatus, which can reliably retain workpieces by means of a simple structure, and further in which the retaining force thereof can suitably be maintained.

In order to achieve the above object, the present invention is characterized by a clamp apparatus for converting linear motion output from a driving section into rotary motion and clamping a workpiece through a clamp arm, the clamp apparatus including:

a body;

a driving section connected to the body and having a displacement rod that is displaceable along an axial direction of the body;

a clamp arm supported rotatably with respect to the body;

a drive force transmission mechanism including a displacement body connected to the displacement rod for displacement along the body, and a link groove extending in an axial direction of the displacement body and through which a spindle that supports an end of the clamp arm is inserted, the drive force transmission mechanism transmitting a drive force from the driving section to the clamp arm, wherein the clamp arm is rotatably displaced by causing displacement of the spindle along the link groove; and

a thrust increasing mechanism disposed in the drive force transmission mechanism for increasing a clamping force when the workpiece is retained by the clamp arm,

wherein the thrust increasing mechanism is made up from an inclined portion, which is formed in the link groove and extends while being inclined at a predetermined angle with respect to an axis of the displacement body, and further, wherein the spindle engages with the inclined portion at a time of clamping when the workpiece is supported by the clamp arm, and wherein the inclined portion causes gradual rotation of the clamp arm via the spindle in a direction for clamping the workpiece.

The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exterior perspective view of a clamp apparatus according to a first embodiment of the present invention;

FIG. **2** is an exploded perspective view of the clamp apparatus shown in FIG. **1**;

FIG. **3** is a side plan view of the clamp apparatus of FIG. **1**;

FIG. **4** is a vertical cross sectional view of the clamp apparatus shown in FIG. **1**;

FIG. **5** is an exploded perspective view of a drive force transmission mechanism that constitutes part of the clamp apparatus shown in FIG. **1**;

FIG. **6** is an exterior perspective view of a clamp arm constituting part of the drive force transmission mechanism of FIG. **5**;

FIG. **7** is a vertical cross sectional view showing a state in which the clamp arm in the clamp apparatus of FIG. **4** is rotated and the held state of a workpiece is released;

FIG. **8** is a conceptual diagram showing a relationship between forces applied with respect to a spindle that supports a clamp arm;

FIG. **9**A is an operational explanatory diagram showing an initial state of clamping by the clamp arm;

FIG. **9**B is an operational explanatory diagram showing a condition in which the clamp arm is further rotated due to further displacement of a guide member;

FIGS. **10**A and **10**B depict a modified example, in which a second groove portion of a second link groove is further extended beyond that of the clamp apparatus shown in FIGS. **9**A and **9**B, wherein FIG. **10**A is an operational explanatory diagram showing an initial state of clamping by the clamp arm, and FIG. **10**B is an operational explanatory diagram showing a condition in which the clamp arm is further rotated due to further displacement of a guide member;

FIG. **11** is an overall cross sectional view of a clamp apparatus according to a second embodiment of the present invention; and

FIG. **12** is a cross sectional view showing a state in which a workpiece is retained by the clamp apparatus of FIG. **11**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, reference numeral **10** indicates a clamp apparatus according to a first embodiment of the present invention.

The clamp apparatus **10**, as shown in FIGS. **1** to **7**, includes a hollow body **12**, a clamp unit **14** disposed on an upper portion of the body **12**, which is capable of retaining a workpiece W (see FIG. **4**), a cylinder (driving section) **18** connected to an end of the body **12**, which is capable of rotating a clamp arm **16** of the clamp unit **14** under the supply of a pressure fluid, and a drive force transmission mechanism **20** disposed in the interior of the body **12**, which is capable of transmitting a drive force from the cylinder **18** to the clamp unit **14**. The workpiece W retained by the clamp apparatus **10**, for example, comprises a panel formed from a plate-like material, which is used in an automobile. The clamp apparatus **10** is used in a production line in which such an automotive panel is retained and is welded.

The body **12** is formed with a substantially rectangular shape in cross section, and includes a through hole **22** formed along an axial direction (the direction of the arrows A and B) in a center portion of the body **12**, a first recess **24** that extends along the axial direction and is formed in the center of an upper surface thereof, and a pair of second recesses **26***a*, **26***b* formed on both side surfaces perpendicular to the upper surface, and which extend in the axial direction. The first and second recesses **24**, **26***a*, **26***b* are formed by recessing the side surfaces of the body **12** at a predetermined depth with a U-shape in cross section, the recesses **24**, **26***a*, **26***b* being formed substantially in parallel with each other.

A guide body (displacement body) **28** constituting the drive force transmission mechanism **20** is disposed displaceably inside of the through hole **22**, and a portion of a piston rod (displacement rod) **30** that makes up the cylinder **18** also is inserted through the through hole **22**.

As shown in FIG. **2**, a mounting hole **32**, which is formed in a cross sectional circular shape and in which the clamp unit **14** is installed, is formed in a central portion of the first recess **24**, and an elliptical shaped opening **34** is provided in the center of the mounting hole **32**. The opening **34** is formed so as to have an elongate axis extending in the lengthwise direction of the first recess **24**, and communicates with the through hole **22**. The clamp arm **16** that makes up the clamp unit **14** is inserted through the opening **34**.

Further, plural bolt holes **36** are disposed in the mounting hole **32**, while being mutually separated by equal distances surrounding the center of the opening **34**.

On the other hand, a discharge hole (hole) **38** is formed at a position facing the opening **34**, while sandwiching the through hole **22** on a lower portion of the body **12**. The through hole **22** and the exterior of the apparatus **10** communicate through the discharge hole **38**. The discharge hole **38** is provided in order to discharge foreign matter, which has invaded inside of the body **12**, to the outside.

Link holes **40** formed substantially centrally in the axial direction, together with pairs of guide holes **42***a*, **42***b*, which are provided respectively on one end side and the other end side of the body **12** centrally about the link holes **40**, are formed on the second recesses **26***a*, **26***b*.

The link holes **40** extend in a perpendicular direction (the direction of arrows C and D in FIG. **4**) to the direction (the direction of arrows A and B) in which the second recesses **26***a*, **26***b* extend, whereas the guide holes **42***a*, **42***b* are formed with predetermined lengths along the extending direction of the second recesses **26***a*, **26***b*. Specifically, the link holes **40** and the guide holes **42***a*, **42***b* are formed so as to be mutually perpendicular with respect to each other.

Further, pairs of guide rails **44***a*, **44***b* are installed respectively on both sides about the guide holes **42***a*, **42***b* in the second recesses **26***a*, **26***b*, such that the guide rails **44***a*, **44***b* are disposed and separated mutually from each other by a predetermined distance. The guide rails **44***a*, **44***b* are formed in straight linear shapes having predetermined lengths, and are affixed along respective inner wall surfaces of the second recesses **26***a*, **26***b*.

The clamp unit **14** includes a cylindrical main body portion **46** installed in the mounting hole **32** of the body **12**, a cap **52** affixed to an upper part of the main body portion **46** through a plate **48** and bolts **50**, and the clamp arm **16**, which is inserted through the interior of the main body portion **46** and the cap **52**, and is rotatable by a drive force from the drive force transmission mechanism **20**.

Additionally, by insertion of the plural bolts **50** through holes of the plate **48**, the cap **52**, and the main body portion **46** and screw-engagement of the bolts **50** into the bolt holes **36** of the body **12**, the clamp unit **14** including the plate **48**, the cap **52** and the main body portion **46** is affixed to an upper portion of the body **12**.

A first arm hole **54**, through which the clamp arm **16** is inserted, is formed in the axial direction in the main body portion **46**, and a link shaft **56** is provided perpendicularly to the first arm hole **54**. The link shaft **56** is inserted through a first link groove **58** of the clamp arm **16** in the interior of the first arm hole **54**.

Further, cutouts (discharge openings) **59** facing the first recess **24** are disposed on a lower portion of the main body portion **46**, the first arm hole **54** communicating with the exterior through the cutouts **59**, which are substantially rectangular in cross section. The cutouts **59** are provided in a pair, and are positioned along a straight line located centrally about the first arm hole **54**. Stated otherwise, the cutouts **59** are disposed respectively upwardly of the first recess **24** (see FIG. **4**).

Furthermore, a rectangular cover **60** is disposed on the lower part of the main body portion **46** between the opening **34** of the body **12** and the main body portion **46**. The cover **60** is formed by a thin plate and is disposed in a position facing the opening **34** of the body **12**. In addition, the width dimension of the cover **60** is set substantially the same as the width dimension of the first recess **24**, so that the cover **60** is disposed for displacement along the first recess. A rectangular insertion hole **62** is formed in the center of the cover **60**, through which the clamp arm **16** is inserted, while also being inserted through the opening **34** of the body **12**.

More specifically, the clamp arm **16** is inserted through the interior of the body **12** and the clamp unit **14** while passing through the insertion hole **62** of the cover **60**. The opening area of the insertion hole **62** is set to be smaller than the opening area of the opening **34**.

The cap **52** is made up of a disk shaped base portion **64** affixed to the main body portion **46**, and a cylindrical portion **66** that projects at a predetermined height with respect to the base portion **64**. A slit hole **68**, through which a portion of the clamp arm **16** can be exposed to the exterior, is provided on a side surface of the cylindrical portion **66**. The slit hole **68** is

formed at a predetermined height from the base portion **64** along the axial direction of the cap **52**.

Further, the cylindrical portion **66** is formed so as to gradually be reduced in diameter in a direction (the direction of the arrow D) separating away from the base portion **64**, the end thereof being formed in a spherical shape. With the cylindrical portion **66**, for example, when an automotive panel or the like is retained, positioning thereof is carried out by insertion of the cylindrical portion **66** through a hole or opening provided in the automotive panel. More specifically, the cylindrical portion **66** constituting the clamp unit **14** includes a positioning function, for carrying out positioning of the workpiece W with respect to the clamp apparatus **10**.

The clamp arm **16** is formed from a block body having a fixed thickness, and includes a predetermined length in the longitudinal direction. A spindle **70** of the drive force transmission mechanism **20** is inserted through one end of the clamp arm **16**, in addition to being inserted into the guide body **28** of the drive force transmission mechanism **20**. Additionally, by insertion of the spindle **70**, which is perpendicular to the longitudinal direction of the clamp arm **16**, through the clamp arm **16** and the guide body **28**, the clamp arm **16** is latched (fixedly engaged) with respect to the guide body **28**.

On the other hand, a claw **72**, which is bent at a right angle with respect to the longitudinal direction of the clamp arm **16**, is disposed on the other end of the clamp arm **16**. The claw **72** is capable of retaining the workpiece W by rotation of the clamp arm **16**.

Further, the first link groove **58** is formed in the center of the clamp arm **16**, such that the link shaft **56** is inserted through the first link groove **58** when the clamp arm **16** is inserted through the interior of the main body portion **46**. The first link groove **58** is constituted of a first groove portion **58***a* formed on the other end side of the clamp arm **16** having the claw **72**, and a second groove portion **58***b* formed on the one end side of the clamp arm **16**. The first groove portion **58***a* extends for a predetermined length parallel to the longitudinal direction of the clamp arm **16**, whereas the second groove portion **58***b* is inclined at a predetermined angle from the joint with the first groove portion **58***a* toward one side surface of the clamp arm **16** that includes the claw **72**. In other words, the second groove portion **58***b* is inclined at a predetermined angle with respect to the direction of extension of the first groove portion **58***a*, and extends toward the one end side of the clamp arm **16**.

The cylinder **18** includes a cylinder tube **74** with a bottomed tubular shape, a piston **76** disposed displaceably inside of the cylinder tube **74**, a piston rod **30** connected to an end of the piston **76**, and a rod cover **78** that closes an end of the cylinder tube **74** and supports the piston rod **30** therein.

The open end of the cylinder tube **74** is connected to the end of the body **12**, with a cylinder cavity **80** being formed in the interior thereof. Further, first and second ports **82**, **84** through which a pressure fluid is supplied and discharged, are formed in a side surface of the cylinder tube **74**, which are disposed and separated from each other by a predetermined distance along the axial direction (the direction of arrows A and B) of the cylinder tube **74**. The first and second ports **82**, **84** communicate respectively through communication passages with the cylinder cavity **80**. That is, the pressure fluid supplied to the first and second ports **82**, **84** is introduced through the communication passages to the interior of the cylinder cavity **80**.

The piston **76** is disposed for displacement along the cylinder cavity **80**, with a piston packing **86** and a magnet **88** being mounted through annular grooves on the outer circumferential surface of the piston **76**. Further, a hole penetrates through the center of the piston **76**, with one end of the elongate piston rod **30** being inserted through and connected to the piston **76**.

The piston rod **30** extends over a predetermined length toward the open end side of the cylinder tube **74**, and is inserted through and supported by the rod hole **90** of the rod cover **78**, while the other end of the piston rod **30** serving as a tip end thereof is inserted into the through hole **22** of the body **12**. An annular rod packing **92** is mounted in the rod hole **90**, so that airtightness of the cylinder cavity **80** is preserved, by the rod packing **92** making sliding contact with the outer circumferential surface of the piston rod **30**.

Further, a connecting hole **94** that penetrates in a direction perpendicular to the axis of the piston rod **30** is formed in the other end of the piston rod **30**, through which a roller axis **96***b* that makes up part of the drive force transmission mechanism **20** is inserted. As a result, the guide body **28** of the drive force transmission mechanism **20** and the piston rod **30** are interconnected, and the guide body **28** is displaced integrally with the piston rod **30** upon displacement of the piston rod **30**.

The drive force transmission mechanism **20** includes the guide body **28**, which is arranged in the through hole **22** of the body **12** and is formed in a block-like shape, two pairs of rotating rollers **98***a*, **98***b* that are retained rotatably on both side surfaces of the guide body **28**, a spindle **70** that is inserted through second link grooves **100** of the guide body **28** and which rotatably supports the clamp arm **16**, and four pairs of guide rails **44***a*, **44***b* disposed on both side surfaces of the body **12** for guiding the rollers **98***a*, **98***b* along the axial directions (the directions of arrows A and B) of the body **12**.

The guide body **28** is formed with a substantially rectangular shape in cross section having a pair of arcuate surfaces, and further is formed with a connecting hole **102** on an end thereof facing the cylinder **18**. The piston rod **30** of the cylinder **18** is inserted into the interior of the connecting hole **102**. Moreover, when the guide body **28** is inserted into the through hole **22** of the body **12**, the pair of arcuate surfaces are arranged in sliding contact respectively with inner wall surfaces of the through hole **22** and are guided along the axial direction of the body **12**, while the arcuate surfaces are disposed respectively on upper and lower sides of the body **12**.

Further, a second arm hole **104** that penetrates in a vertical direction (the direction of arrows C and D) perpendicular to the axial direction is formed in a center portion of the guide body **28**, and the one end of the clamp arm **16** is inserted into the second arm hole **104**. More specifically, the second arm hole **104** is disposed so as to face toward the opening **34** when the guide body **28** is positioned inside of the body **12** (see FIG. **4**).

On the other hand, both side surfaces of the guide body **28** are formed in flat shapes, in contrast to the pair of arcuate surfaces, and further are formed with respective second link grooves **100** therein, which penetrate therethrough along with the second arm hole **104**. The second link grooves **100** are each formed in the same shape on one side surface and the other side surface of the guide body **28**, and the spindle **70**, which is inserted through the one end of the clamp arm **16**, is inserted respectively through the second link grooves **100**.

Each of the second link grooves **100** includes a first groove portion **100***a*, which is formed on one end side of the guide body **28** that includes the connecting hole **102**, and a second groove portion (inclined portion) **100***b*, which is joined to the first groove portion **100***a* and extends toward the other end side of the guide body **28**. More specifically, the spindle **70** is disposed for displacement along the first groove portion **100***a* and the second groove portion **100***b*, which make up the second link groove **100**.

The first groove portion **100***a* is formed substantially parallel to the axis of the guide body **28**, whereas the second groove portion **100***b* extends while being inclined downwardly somewhat with respect to the axis of the guide body **28**.

The rotating rollers **98***a*, **98***b* are rotatably disposed through a pair of roller axes **96***a*, **96***b*, which are provided respectively on the one end and the other end of the guide body **28**, and are separated by a predetermined distance with respect to both side surfaces of the guide body **28**. Specifically, the rotating rollers **98***a*, **98***b* are disposed respectively on both ends of the roller axes **96***a*, **96***b*, and further, are disposed in pairs respectively on the one end and the other end of the guide body **28**.

Further, one of the roller axes **96***a*, **96***b* disposed on one end of the guide body **28** is inserted through the interior of the connecting hole **102**, and also is inserted through the connecting hole **94** of the piston rod **30**. Owing thereto, the guide body **28** and the piston rod **30** are interconnected, whereby the guide body **28** is displaceable along the axial directions (in the directions of arrows A and B) under a driving action of the cylinder **18** including the piston rod **30** thereof.

In addition, when the guide body **28** is disposed in the through hole **22** of the body **12**, the roller axes **96***a*, **96***b* are inserted respectively through the guide holes **42***a*, **42***b* of the body **12** and project outside, and the rotating rollers **98***a*, **98***b* are mounted for rotation respectively on both ends thereof. The rollers **98***a*, **98***b* are disposed respectively between the pairs of guide rails **44***a*, **44***b*, so that when the guide body **28** is displaced along the axial direction, the rollers **98***a*, **98***b* move along the guide rails **44***a*, **44***b* while rotating. That is, displacement of the guide body **28** in the axial direction is guided by the rollers **98***a*, **98***b* and the guide rails **44***a*, **44***b*.

The clamp apparatus **10** according to the first embodiment of the present invention is constructed basically as described above. Next, explanations shall be made concerning operations and effects of the invention.

First, the clamp apparatus **10** is fixed in a predetermined position through a non-illustrated fixing mechanism, while non-illustrated pipings or the like connected to a pressure fluid supply source are connected respectively to the first and second ports **82**, **84**. In FIGS. **1**, **2** and **4**, the clamp apparatus **10** is shown in a clamped state, whereas in FIG. **7**, the clamp apparatus is shown in an unclamped state. Below, the aforementioned unclamped state shall be described as defining an initial state.

In the initial state of the clamp apparatus **10** shown in FIG. **7**, a pressure fluid is supplied to the first port **82** from a non-illustrated pressure fluid supply source, and the pressure fluid is introduced into the cylinder cavity **80**. In this case, the second port **84** is placed in a state of being open to atmosphere.

Under an action of the pressure fluid introduced into the cylinder cavity **80**, the piston **76** is pressed in a direction (the direction of the arrow A) to separate away from the body **12**, and the piston **76** is displaced along the cylinder cavity **80** (see FIG. **4**). In addition, the guide body **28** is displaced together with the piston **76** and the piston rod **30**, and the guide body **28** is displaced toward the side of the cylinder **18** (in the direction of the arrow A) under the guidance of the rotating rollers **98***a*, **98***b* on the guide rails **44***a*, **44***b*. In this case, the rollers **98***a*, **98***b* are displaced while rotating between the pair of guide rails **44***a*, **44***b*.

Additionally, by displacement of the guide body **28** along the through hole **22** of the body **12**, the spindle **70** inserted through the second link grooves **100** moves from the first groove portion **100***a* to the second groove portion **100***b* thereof, and the spindle **70** is pressed downward (in the direction of the arrow C) gradually along the second link grooves **100**. In this case, because the spindle **70** is inserted through the link hole **40** of the body **12**, the spindle **70** is not displaced in the axial direction (the direction of arrows A and B) of the body **12**, but is displaced only in a vertical direction (the direction of arrows C and D).

As a result, the clamp arm **16** in which the spindle **70** is axially supported is displaced downward (in the direction of the arrow C) in its entirety in the first and second arm holes **54**, **104**, and the link shaft **56**, which is inserted through the center portion of the clamp arm **16**, moves from the second groove portion **58***b* toward the first groove portion **58***a* of the first link groove **58**. Together therewith, the clamp arm **16** is rotated counterclockwise (in the direction of the arrow F) through a predetermined angle about the one end side of the clamp arm **16** in which the spindle **70** is axially supported. More specifically, the clamp arm **16** is rotationally displaced counterclockwise (in the direction of the arrow F) about the spindle **70** while the clamp arm **16** is displaced in a downward direction.

In addition, by abutment of the claw **72** disposed on the other end of the clamp arm **16** against the upper surface side of the workpiece W, the workpiece W is retained between the claw **72** and the plate **48** (see FIG. **4**).

Further, when the clamp arm **16** is rotated and the workpiece W is retained, although a structure is provided in which the spindle **70** is displaced downwardly (in the direction of the arrow C) along the second link grooves **100** by displacement of the guide body **28**, because the second groove portion **100***b* of the second link groove **100** is formed so as to be inclined in a downward direction somewhat with respect to the axis of the guide body **28**, along with displacement of the guide body **28**, the spindle **70** is pulled gradually downward.

Owing thereto, the clamp arm **16** that supports the spindle **70** also is pulled gradually downward (in the direction of the arrow C), and because the clamp arm **16** is rotated such that the claw **72** of the clamp arm **16** progresses even further toward the side of the workpiece W, the workpiece W can be retained more reliably and with greater strength. That is, the second groove portion **100***b* of the second link groove **100** functions as a thrust increasing mechanism, which is capable of increasing the force at which the workpiece W is retained by the clamp arm **16**.

In greater detail, as shown in FIG. **8**, the thrust force F**1** (displacement force) from the cylinder **18**, which is imposed with respect to the guide body **28**, and the clamping force F**2** by the clamp arm **16**, can be represented by vectors as illustrated in the figure. Specifically, with the aforementioned thrust force increasing mechanism, the thrust force F**1** from the cylinder **18** is applied along the axial direction of the cylinder **18**, whereas the clamping force F**2** by the clamp arm **16** is applied in a vertically downward direction perpendicular to the axial direction. Additionally, accompanying an increase in the thrust force F**1** from the cylinder **18**, the clamping force F**2** on the workpiece W by the clamp arm **16** can also be increased.

Further, at this time, because the cover **60** through which the clamp arm **16** is inserted is displaced along the first recess **24** accompanying rotary movement of the clamp arm **16**, the opening **34** of the body **12**, which is covered by the cover **60**, is not opened or unblocked as a result of the rotary movement of the clamp arm **16**, and remains continuously closed and blocked even during times when the clamp arm **16** is moved.

Further, from the initial clamped state by the clamp arm **16** shown in FIG. **9**A, as shown in FIG. **9**B, by further displacement of the guide body **28** in the direction of the arrow A so

that the spindle **70** is moved to the end of the second groove portion **100***b* within the second link groove **100**, the clamp arm **16** is displaced further downward to achieve a fixed clamping force. In this manner, the workpiece W can be retained within a clamping range, from the initial clamping state shown in FIG. **9**A to the maximum clamping state shown in FIG. **9**B. Owing thereto, even in the case that a variance exists in the thickness of the workpieces W, such a variance can easily be responded to.

On the other hand, in the event that switching is carried out from the clamped state of the workpiece W shown in FIG. **4** to an unclamped state, under a switching action of an unillustrated changeover valve, the supply of pressure fluid to the first port **82** is stopped, and by supplying the pressure fluid to the second port **84**, the piston **76** is displaced toward the side of the body **12** (in the direction of the arrow B). In this case, the first port **82** is placed in a state of being open to atmosphere. In addition, by displacement of the piston **76** and the piston rod **30** toward the side of the body **12**, the spindle **70** inserted through the guide body **28** is moved from the second groove portion **100***b* toward the first groove portion **100***a* of the second link groove **100**, and together therewith, the clamp arm **16** is displaced upwardly (in the direction of the arrow D) along the first and second arm holes **54**, **104** together with the spindle **70**.

Along therewith, the clamp arm **16** is rotated gradually clockwise (in the direction of the arrow E) about the spindle **70** through an engagement action of the link shaft **56**, which is inserted through the first link groove **58**.

As a result, the claw **72**, which is disposed at the other end of the clamp arm **16**, gradually separates from the workpiece W, and the clamped state of the workpiece W by the claw is released to provide an unclamped state.

In the foregoing manner, in the first embodiment, the spindle **70** that supports the end of the clamp arm **16** is inserted through the second link grooves **100** of the guide body **28**, and moreover, the second link groove **100** is made up from a first groove portion **100***a*, which is substantially parallel with the axis of the guide body **28**, and a second groove portion **100***b*, which is inclined downwardly with respect to the axis of the guide body **28**. Additionally, the spindle **70** is displaced in upward and downward directions along the second link groove **100** under a displacement action of the guide body **28**, which is displaced through the cylinder **18**, and along therewith, the clamp arm **16** is rotated by a predetermined angle through the link shaft **56** inserted through the first link groove **58**, thereby providing clamped and unclamped states.

At this time, because the second groove portion **100***b* of the second link groove **100** is inclined downwardly with respect to the axis of the guide body **28**, when the spindle **70** engages within the second groove portion **100***b*, the spindle **70** is pulled gradually downward, whereupon the clamp arm **16** can be rotated toward the side of the workpiece W. As a result, in the clamped state, since the claw **72** of the clamp arm **16** can be pressed further with respect to the workpiece W, the workpiece W can be retained more reliably and with greater strength. That is, while the workpiece W is retained, the thrust force by the clamp arm **16** can be increased.

Stated otherwise, even in the case that a variance exists in the thickness of the workpieces W, the surface of the workpiece W can be reliably and suitably pressed by the claw **72** of the clamp arm **16**, and the workpiece W can be retained between the claw **72** of the clamp arm **16** and the plate **48**.

Furthermore, as shown in FIGS. **10**A and **10**B, by adjusting the length of the second groove portion **100***b* in the second link groove **100**, the retainment range (clamping range) of the workpiece W during the clamping period of the clamp arm **16** can freely be adjusted. Specifically, by setting the length of the second groove portion **100***b* to be longer, the retainment range of the maximum clamping force by the clamp arm **16** can be increased (see FIG. **10**B).

More specifically, the workpiece W is capable of being retained within a clamping range from the initial clamping state by the clamp arm **16** shown in FIG. **10**A to the clamped state shown in FIG. **10**B, and because the clamping range can easily be enlarged by setting a longer length for the second groove portion **100***b*, in the case of a variance in the width of the workpiece W, a greater tolerance range can be provided.

Further, the cover **60** is disposed over the opening **34** of the body **12**, and the clamp arm **16** is inserted through the insertion hole **62**, with the cover **60** being disposed displaceably along the first recess **24** of the body **12**. Accordingly, for example, in the case that the clamp apparatus **10** is used on a welding line or the like for automobiles, invasion of foreign objects such as spatter or the like into the interior of the body **12** can be prevented. Furthermore, in the unlikely event that spattered foreign objects do enter into the body **12**, such foreign objects can be discharged to the outside from the discharge hole **38** that is opened at the lower part of the body **12**.

As a result, invasion of foreign matter into the interior of the body **12** containing the drive force transmission mechanism **20** therein can be prevented. Further, even in the case that such matter does invade into the body **12**, since the foreign matter can easily be discharged to the outside, proper operation of the clamp arm **16** and the drive force transmission mechanism **20** is not impeded, and the clamp apparatus **10** can be smoothly operated. In addition, maintenance of the clamp apparatus can be facilitated and improved.

Next, a clamp apparatus **150** according to a second embodiment is shown in FIGS. **11** and **12**. Structural features which are the same as those of the clamp apparatus **10** according to the first embodiment are designated by the same reference numerals, and detailed explanation of such features is omitted.

The clamp apparatus **150** according to the second embodiment differs from the clamp apparatus **10** according to the first embodiment in that, instead of providing the cylinder **18** (see FIG. **4**) which enables rotation of the clamp arm **16** under the supply of a pressure fluid, the clamp apparatus **150** is equipped with an operating section **152** which enables rotary movement of the clamp arm **16** manually, wherein the held state of the workpiece W can be switched by manual operation of the operating section **152** by an operator.

In the clamp apparatus **150**, as shown in FIGS. **11** and **12**, the operating section **152** is connected to an end of the body **12**. The operating section **152** includes a housing **154** connected to the body **12**, a connecting rod (displacement rod) **156** connected to the guide body **28** constituting the drive force transmission mechanism **20**, a link arm **158** pivotally supported rotatably on the housing **154**, and an operating lever (handle) **160** connected to the link arm **158** and to the connecting rod **156**, and which is capable of being manually operated by an operator.

The connecting rod **156** is inserted displaceably through the interior of the housing **154** and is displaced in the axial direction of the body **12** and the housing **154**. One end of the connecting rod **156** is connected to an end of the guide body **28** by means of a roller axis **96***b* inserted through the connecting hole **162**. The other end of the connecting rod **156** is axially supported through a connecting shaft **164** at one end of the operating lever **160**.

The link arm **158** is provided on an end of the housing **154**, one end of the link arm **158** being pivotally supported rotatably through a support shaft **166**. A link shaft **168** is axially supported at the other end of the link arm **158**, and is rotatable by insertion through an oblong link hole **170** formed in a center portion of the operating lever **160**.

The operating lever **160** is formed with a predetermined length, wherein one end of the operating lever **160** is pivotally supported at the other end of the connecting rod **156**, and a spherical gripping member **172**, which is easily grasped by the operator, is disposed on the other end of the operating lever **160**.

Next, operations of the clamp apparatus **150** having the aforementioned operating section **152** shall briefly be explained.

First, in an unclamped state of the workpiece W as shown in FIG. **11**, the operating lever **160** making up the operating section **152** is in a state of being inclined about the connecting shaft **164** at a predetermined angle in a direction away from the body **12** (in the direction of the arrow E). In addition, in the case that the workpiece W is to be clamped, an operator (not shown) grasps the gripping member **172**, and rotates the operating lever **160** toward the side of the body **12** (in the direction of the arrow F).

Accordingly, accompanying rotary movement of the operating lever **160**, the other end side of the link arm **158** is rotatably displaced toward the side of the body **12** about the support shaft **166**, and the connecting rod **156**, which is connected to one end of the operating lever **160**, is pulled in a direction (the direction of arrow A) away from the body **12**. At this time, the link shaft **168** moves along the link hole **170** of the operating lever **160**. As a result, together with the connecting rod **156**, the guide body **28** is displaced along the body **12**, and the spindle **70** inserted through the second link grooves **100** is pressed downward (in the direction of the arrow C). Along therewith, by downward displacement of the clamp arm **16**, the claw **72** is rotated counterclockwise by a predetermined angle so as to face the workpiece W. As a result, the claw **72** of the clamp arm **16** abuts against the upper surface of the workpiece W, providing a clamped state (see FIG. **12**) in which the workpiece W is clamped and retained between the claw **72** and the plate **48**.

On the other hand, in the clamped state shown in FIG. **12**, in the case that the unclamped state is restored again, the operator (not shown) grasps the operating lever **160**, and by rotating the operating lever **160** in a direction away from the body **12** (in the direction of the arrow E) about the connecting shaft **164**, the connecting rod **156** is displaced so as to be pressed inwardly toward the side of the body **12**. Owing thereto, the guide body **28** connected to the connecting rod **156** is displaced along the axial direction in a direction away from the operating section **152**. As a result, the spindle **70** inserted through the second link grooves **100** is displaced upwardly (in the direction of the arrow D), and along therewith, by upward displacement of the clamp arm **16**, the clamp arm **16** is rotated clockwise by a predetermined angle so that the claw **72** moves away from the workpiece W. Thus, the clamped state of the workpiece W by the claw **72** of the clamp arm **16** is released, resulting in an unclamped state.

In the foregoing manner, in the second embodiment, in place of the cylinder **18** used in the first embodiment, an operating section **152** operable by manual operations of an operator is provided, wherein the clamped state of the workpiece W by the clamp arm **16** can be switched by operation of the operating section **152**. Owing thereto, there is no need to provide the pressure fluid supply source or pipes for supplying the pressure fluid, and clamped and unclamped states of the workpiece W can be switched by means of a simple structure. Further, since the operating section **152** can provide a simpler structure compared to the cylinder **18**, the number of parts can be reduced, along with enabling reductions in manufacturing costs and the number of assembly steps.

The clamp apparatus according to the present invention is not limited to the above embodiments, and it is a matter of course that various alternative or additional structures could be adopted without departing from the essence or gist of the present invention.

What is claimed is:

1. A clamp apparatus for converting linear motion output from a driving section into rotary motion and clamping a workpiece through a clamp arm, the clamp apparatus comprising:

a body;

a driving section connected to the body and having a displacement rod that is displaceable along an axial direction of the body;

a clamp arm supported rotatably with respect to the body;

a drive force transmission mechanism including a displacement body connected to the displacement rod for displacement along the body, and a link groove extending in an axial direction of the displacement body and through which a spindle that supports an end of the clamp arm is inserted, the drive force transmission mechanism transmitting a drive force from the driving section to the clamp arm, wherein the clamp arm is rotatably displaced by causing displacement of the spindle along the link groove; and

a thrust increasing mechanism disposed in the drive force transmission mechanism for increasing a clamping force when the workpiece is retained by the clamp arm,

wherein the thrust increasing mechanism is made up from an inclined portion, which is formed in the link groove and extends while being inclined at a predetermined angle with respect to an axis of the displacement body, and further, wherein the spindle engages with the inclined portion at a time of clamping when the workpiece is supported by the clamp arm, and wherein the inclined portion causes gradual rotation of the clamp arm via the spindle in a direction for clamping the workpiece, and

wherein the body includes an opening through which the clamp arm is inserted, a cover being installed over the opening and capable of displacement along the axial direction of the body.

2. The clamp apparatus according to claim **1**, wherein the displacement body includes a guide mechanism for guiding the displacement body along the axial direction of the body.

3. The clamp apparatus according to claim **1**, wherein the body includes a link hole therein for guiding the spindle along a direction perpendicular to the axis of the body.

4. The clamp apparatus according to claim **1**, wherein the driving section comprises a cylinder having a piston to which the displacement rod is connected, and which is displaced in the axial direction of the body under a pressing action of a pressure fluid.

5. The clamp apparatus according to claim **1**, wherein a hole is formed in a lower part of the body communicating between the interior and the exterior of the body, wherein dust in the interior of the body may be discharged to the exterior through the hole.

6. The clamp apparatus according to claim **1**, wherein a clamp unit including the clamp arm therein comprises a main body portion disposed on an upper part of the body, which supports the clamp arm tiltably through a link shaft, the main

body portion including a discharge opening for discharging foreign matter eliminated through the cover.

7. The clamp apparatus according to claim **1**, wherein the cover includes an insertion hole therein through which the clamp arm may be inserted, an opening area of the insertion hole being set smaller than an opening area of the opening.

8. The clamp apparatus according to claim **1**, wherein the cover is displaceable, accompanying rotational movement of the clamp arm, along a recess disposed in the body.

9. A clamp apparatus for converting linear motion output from a driving section into rotary motion and clamping a workpiece through a clamp arm, the clamp apparatus comprising:

a body;

a driving section connected to the body and having a displacement rod that is displaceable along an axial direction of the body;

a clamp arm supported rotatably with respect to the body;

a drive force transmission mechanism including a displacement body connected to the displacement rod for displacement along the body, and a link groove extending in an axial direction of the displacement body and through which a spindle that supports an end of the clamp arm is inserted, the drive force transmission mechanism transmitting a drive force from the driving section to the clamp arm, wherein the clamp arm is rotatably displaced by causing displacement of the spindle along the link groove;

a guide mechanism for guiding the displacement body along the axial direction of the body, the guide mechanism comprising a plurality of guide rails fixed to the body and extending in the axial direction of the body, and a plurality of rollers rotatably provided at the displacement body for movement with the displacement body along the axial direction of the body, the rollers cooperating with the guide rails to guide the displacement body along the axial direction of the body; and

a thrust increasing mechanism disposed in the drive force transmission mechanism for increasing a clamping force when the workpiece is retained by the clamp arm,

wherein the thrust increasing mechanism is made up from an inclined portion, which is formed in the link groove and extends while being inclined at a predetermined angle with respect to an axis of the displacement body, and further, wherein the spindle engages with the inclined portion at a time of clamping when the workpiece is supported by the clamp arm, and wherein the inclined portion causes gradual rotation of the clamp arm via the spindle in a direction for clamping the workpiece.

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